Design and Use of
Earth Observation Image Content Tools

Mihai Datcu\textsuperscript{(1, 2)}, Daniele Cerra\textsuperscript{(1)}, Houda Chaabouni-Chouayakh\textsuperscript{(1)},
Amaia de Miguel\textsuperscript{(1)}, Daniela Espinoza Molina\textsuperscript{(1)}, Gottfried Schwarz\textsuperscript{(1)},
Matteo Soccorsi\textsuperscript{(1)}

\textsuperscript{(1)} German Aerospace Center (DLR)
\textsuperscript{(2)} Télécom ParisTech
How Can We Identify Images By Content

Satellite images
- optical images (spectral channels, resolution)
- SAR images (bands, polarization, resolution)

Applications
- commercial and institutions
- science and technology

State of the art
- pixel data, metadata, toolboxes
- archives, catalogues, information systems, user interfaces
- services
Hurricane Image  http://visibleearth.nasa.gov/view_rec.php?id=7938
Typhoon Image

SAR Image of a Mountain http://www.infoterra.de/tsx/freedata/start.php
The Gap Between Applications and Available Data

Typical image processing issues
- Identification of a cyclone compared to other features or cloud patterns (spectral bands, feature analysis)?
- Determination of its track, speed and landfall (time series of images, motion vectors)?
- What additional information do we need (geographical data, geophysical parameters)?
- Which precision and accuracy can we reach (test runs, use of reference data from image archives)?

Typical geophysical issues
- How can we estimate the actual precipitation?
- How can we predict cyclones?
- Does climate change affect cyclones (occurrence, location, strength, size)?
- How accurate are these predictions (model verification)?
How To Bring Applications Closer To The Data

Goals

● Application-independent methods to identify and classify the content of images (above the pixel level)
● Support individual application-dependent user queries (e.g., train a “semantic” phenomenon, find typical images)

Solution Strategy

● Append additional information to image products; keep all pixels intact
● Extract basic features from all images, generate feature maps
● Append feature maps to products
● Support user interaction (feature browser, etc.)
● Then: cluster features, classification, higher level relationships
Step 1: Typical Interoperable Features

- Depending on image type (amplitude distributions, available models):
  - low or high resolution images
  - optical or SAR images

- High resolution SAR images [Popescu et al., 2009]:
  - generate and de-noise sub-windows

  Compute for each sub-window
  - mean value and variance
  - spectral centroid in along-track and across-track direction
  - spectral flux in along-track and across-track direction
  - entropy
Step 2: Knowledge-based Earth Observation and Image Mining (KIM System, Datcu et al., 2003)
Example: Classification and Detection of Built-up Areas
Example: Detection of Water Bodies
Step 3: Knowledge-based Image Information Mining
KEO System, http://earth.esa.int/rtd/Projects/KEO/
KEO: Interactive, User Adapted, Image Content Access
Step 4: Category-based Semantic Image Search Engine

Goal
An interactive tool to help image analysts to explore image content, detect objects, patterns and structures in large image volumes.

Concept (Costache et al., 2008)
Support Vector Machines (SVMs) and Bayesian inference

Applications
Object detection and context understanding
Recognition of smallest-scale objects
Identification of damaged infrastructure
Detection of changes, counting of people and objects
Mapping and humanitarian aid
Clouds
Sea
Desert
Buildings
Forest
Fields
Airports
Villages
Savanna
Ships
Roundabouts
Use Case: Damage Assessment (Courtesy JRC/IPSC)
Conclusion and Outlook

What do we need for the Sentinel era?